Type Ia Supernova Inference: Hierarchical Bayesian Statistical Models in the Optical and Near Infrared
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Type Ia Supernova (Standard Candles?)

Dust

Light Curve (Time Series)

Cosmology

SN2005el (CfA3+PTEL)

Obs. Days Since B\textsubscript{max}

Obs. Mag. \textbullet m\textsubscript{w}\text{x}

B + 2

H - 9

J - 7

I - 4

R - 2

V

Distance Modulus (mag)

Redshift

CMML-NIPS, 16 Dec 2011
Statistical inference with SN Ia

- SN Ia cosmology inference based on empirical relations
- Statistical models for SN Ia learn from the data
- Several Sources of Randomness & Uncertainty
  1. Photometric Measurement errors
  2. “Intrinsic Variation” = Population Distribution of SN Ia
  3. Random Peculiar Velocities of Galaxies in Hubble Flow
- Observed Data Distributions are convolutions of effects
- How to incorporate this all into a coherent statistical model? (How to de-convolve?)
- Optimal Extraction of Information to Predict Distances
SN Ia Inference with Hierarchical Bayes Models

Strategy: Build Structured Generative Probabilistic Model

- Intrinsic SN Ia Variation (Covariance[\(t, \lambda\)] )
- Host Galaxy Dust Extinction & Reddening
- Galaxy Peculiar Velocities & Distance
- Measurement Error

- Global Posterior Probability Density conditional on all SN data
- Compute using MCMC with Gibbs Sampling structure (BayeSN)

“Training” - Learn about Populations

Directed Acyclic Graph / Bayesian Network
Application to Optical+NIR SN Ia Data & Results

Inferences for Individual SN Ia

Opt+NIR SN Ia LC Fit

Opt+NIR Dust Estimates

NIR narrows constraints on dust and distance

Insights into Dust Properties

Inferences for Population

NIR increases precision of CV distance predictions by ~2x

Low Correlation btw Opt and NIR Luminosities

Peak $M_F$

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